THE POSTORBITAL WALL
A COMPARATIVE AND ETHNOLOGICAL STUDY

By M. R. Hone *

[Read 8 November 1951]

SUMMARY

The paper surveys the formation of the posterior wall of the orbit on a comparative basis. The wall is developed essentially by the extension of bony flanges from the frontal, sphenoid and zygomatic bones. The maxilla may take part. With growth of the wall communication between the orbit and the temporal and infratemporal regions becomes restricted to a narrow fissure. The wall is most complete and the fissure narrowest in the Cercopithecidae, the orang and the gorilla. The gibbon and chimpanzee have wider fissures. The human condition resembles that of the chimpanzee. Human skulls show a wide range of variation in shape and size of the fissure. Statistical analysis discloses no ethnological significance in this.

INTRODUCTION

The bones and general arrangement of the orbit in various orders have been described by many authors, e.g., Duckworth (1904), Whitnall (1921), Martin (1928), Le Gros Clark (1934). This paper presents a general survey of the formation and closure of the postorbital wall, followed by more detailed study of the human condition to determine whether or not the bony pattern has any ethnological significance. The animals discussed in the first part of this paper have been chosen less to suggest a close evolutionary pattern than as affording a good example of each stage of development.

ONTOGENESIS

Submammalia

In fishes, the orbit is composed of a prefontal, postfrontal, frontal, and a varying number of bones on the ventral border grouped as lacrimals (Owen, 1868). Medially, the base of the eye is separated from its partner by the presphenoid.

In the frog the eyes face laterally and are surrounded by the parietal, frontal, sphenoid, ethmoid, nasal and maxilla. There is no bone posteriorly.

In reptiles the orbital margin is composed of the following five bones: jugal, postorbital, frontal, lacrimal, and maxilla. An example is seen in the skull of *Trachysaurus rugosus* (fig. 1), which shows a jugal bone laterally, a postorbital and frontal above, a lacrimal and part of the maxilla in front, and the rest of the maxilla below. Separation of the eyes is as in fishes. The eye still faces laterally. The medial and posterior surfaces of the eye have no bony protection but are adequately supported by muscle.

In birds, although the eye still faces laterally, there is usually greater bony protection. An interorbital septum, either complete or incomplete has developed out of the prefrontals, while the lacrimals and the postorbitals afford additional support.

* Department of Anatomy, University of Adelaide.

Mammalia

The skulls examined were:

Rodentia		
Suborder Lagomorpha		
Family Leporidae	*Oryctolagus cuniculus*	1
Carnivora		
Family Canidae	*Vulpes vulpes*	1
Family Felidae	*Felis cattus*	1
Primates		
Suborder Prosimii	*Lemur varius*	1
Suborder Anthropoidea		
Superfamily Cercopithecidae	*Papio babuin*	1
	Cynocephalus sp.	1
	Cercopithecus tantalus	1
	Macacus rhesus	4
	Macacus fascicularis	1
Superfamily Hominoidea		
Family Pongidae	*Hylobates*	1
	Simia	1
	Gorilla	1
	Anthropithecus	3

The Rabbit (fig. 2)

The cranial wall of the orbit is formed by two upward projections of the basi-cranium, namely, the orbito-sphenoid (anterior or lesser wing) and the ali-sphenoid (posterior or greater wing). The remainder is formed of membrane bone, the frontal and jugal part of the squamosal (Bensley, 1918). The apex of the orbital cavity extends practically to the midline. Above, the frontal bone slopes laterally and upwards; below, the sphenoids slope laterally and downwards. The cranium bulges laterally behind so that the eye is given adequate protection at the back by the frontal and the temporal bones and the frontal carries a small posterior superior orbital process above.

The Fox (fig. 3)

The bony orbit is formed by the frontal, lacrimal, jugal, and ali- and orbito-sphenoid. The apex of the orbital cavity does not extend as far towards the midline as in the rabbit, but the orbit is just as deep relatively because the jugals stand out further from the side of the skull, and they run straight on to the sides of a much rounder cranium. Behind the orbit the cranial wall, composed of sphenoid and frontal, is so far removed from the eye that it gives little protection or support. Hence the posterior superior orbital process is larger and there is a distinct inferior process on the jugal as well. The larger post-orbital processes of the frontal and jugal, combined with the upward direction of the jugal bone as it runs backwards, almost complete the fourth side of the bony margin round the orbit.

The direction of the orbit changes with the species. In the fox the axis points more anteriorly than in the rabbit although its general direction is still lateral. But in short-faced dogs such as the pekingese the eyes have moved more towards the front (Weidenreich, 1941). However, there does not appear to be any compensatory enlargement of the posterior orbital processes in this condition.

The Cat (fig. 4)

The bony walls of the orbit are generally similar to those in the dog but the skull is shorter and wider and the orbit faces more anteriorly. Thus, there is no longer a frontal wall as in preceding specimens. The greater width of the cranium has pushed the jugal process of the temporal bone laterally and so the lateral wall of the orbit (the jugal bone) is also displaced laterally. The cranial wall still forms the posterior orbital wall but, as in the dog, because of the frontal position of the orbit, gives little protection or support to the orbital contents. The posterior orbital processes are much better developed than in the dog.

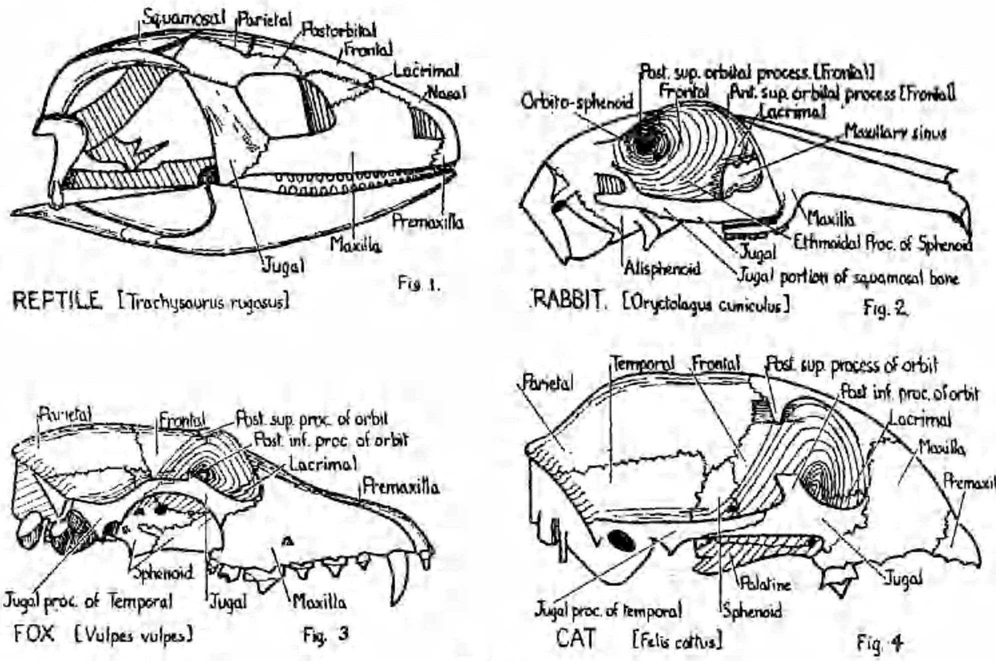


Fig. 1 - 4

THE LEMUR (fig. 5)

The suture lines were fused in the skull available but the boundaries of most of the bones were distinguishable. The eyes are directed almost to the front, the post-orbital bar is complete and there is just a hint of the posterior orbital wall forming. The jugal bone runs up the posterior side of the orbital bar and so forms the beginning of the posterior wall. The frontal helps by providing a roof for the orbit, which extends laterally and slightly posteriorly as well. Medially the orbit is closed behind by the cranial wall but laterally the orbit opens freely into the temporal fossa.

Mention must be made here of a specimen of the flying "lemur" of Malaya (*Galeopithecus volans*) in the Adelaide Museum. This is not a true lemur but it shows an interesting transitional stage. The postorbital bar is not quite complete, but the gap is filled by a bar of cartilage.

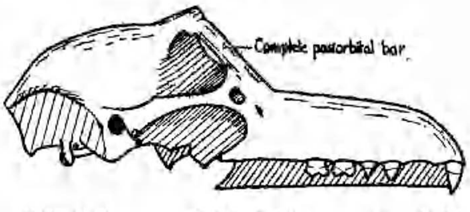
THE TARSIER (fig. 6)

Unfortunately, no skull of the tarsier was available, but there are many good accounts of the osteology of *Tarsius spectrum*.

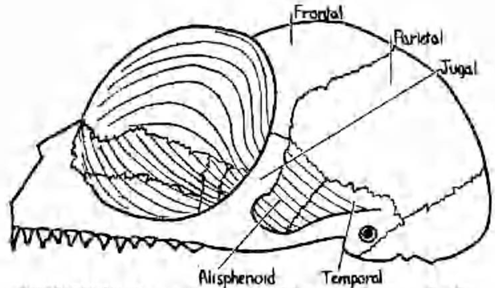
The postorbital bar is completed by the union of processes from the jugal and frontal (Wood Jones, 1929). Above, the frontal sends a flange posteriorly to meet the parietal; below, the jugal meets the sphenoid in a similar manner, but leaving a gap underneath. This gap is bordered by the sphenoid, palatine and maxilla and represents the inferior orbital fissure of other primates.

THE MACAQUES

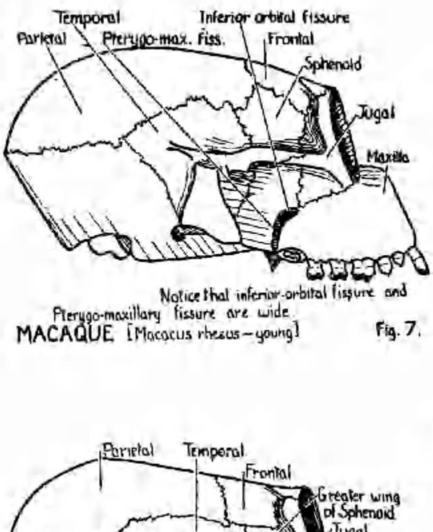
Two species were examined, one adult *Macacus fascicularis,* and two adult and two young specimens of *Macacus rhesus.* The posterior wall is thick and well formed. The inferior orbital fissure is small and in most cases the sphenoid overlaps the maxilla in a curved manner so that the opening practically faces caudally.



LEMUR [Lemur varius] The suture lines were fused Fig 5



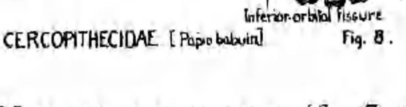
TARSIER [Tarsius spectrum Wood Jones 1929] Fig. 6.



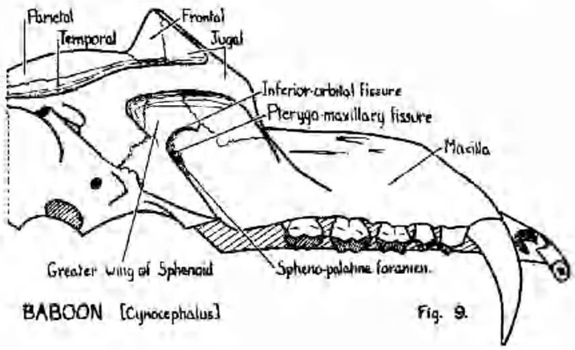
Notice that inferior-orbital fissure and Pterygo-maxillary fissure are wide.
MACAQUE [Macacus rhesus – young] Fig. 7.

Skull no 2 Skull no. 3 Skull no. 4

Fig. 7. [cont'd]



CERCOPITHECIDAE [Papio babuin] Fig. 8.



BABOON [Cynocephalus] Fig. 9.

Fig. 5 - 9

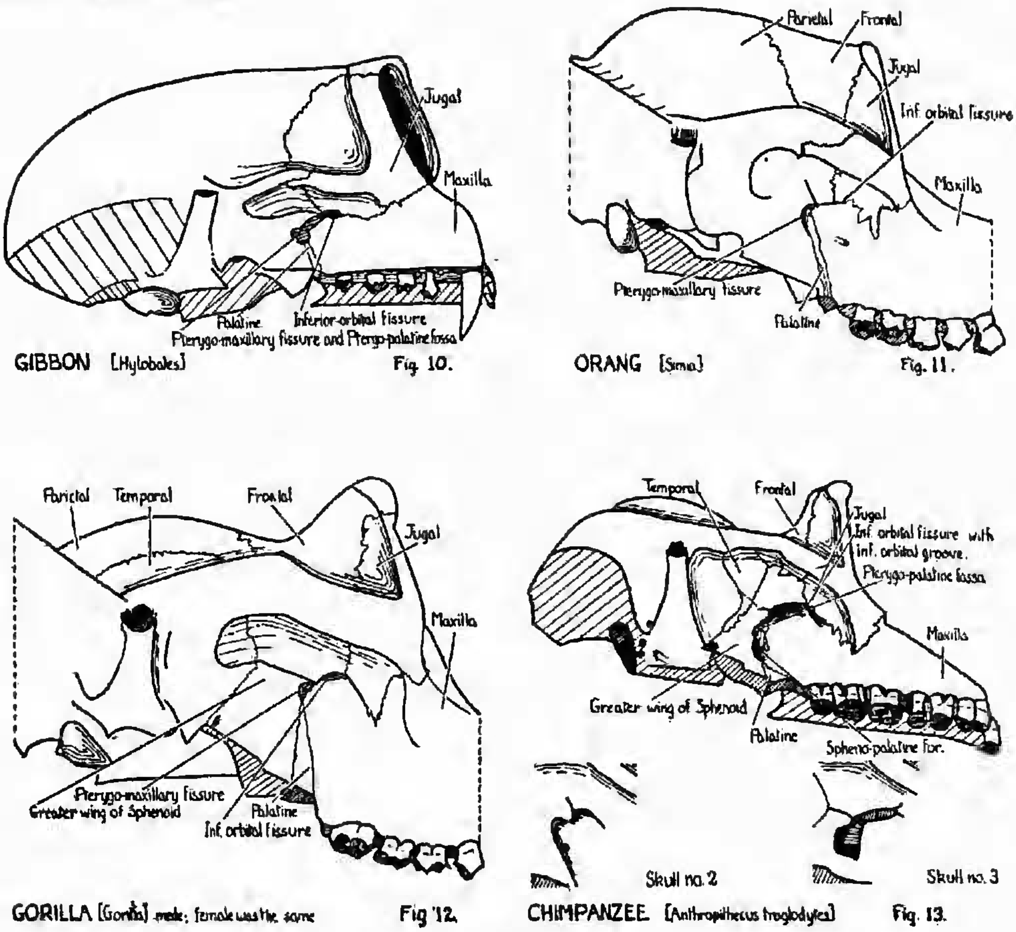
MACACUS FASCICULARIS (fig. 7, skull No. 4)

In this specimen, three bones form the boundaries of the inferior orbital fissure: the greater wing of the sphenoid, the jugal and the maxilla. The fissure is directed caudally; the sphenoid forms the lateral border and the maxilla the medial border. The jugal forms the tip, being almost excluded by the other two bones. The frontal bone forms the main part of the postorbital wall, with the sphenoid and jugal forming the basal and lateral portions respectively.

Macacus rhesus (fig. 7, skulls No. 1, 2 and 3)

The arrangement of the bones round the inferior orbital fissure is the same as in the above specimen, but the proportions of the postorbital bones differ. The frontal takes a very small part, most of the wall being formed by the sphenoid and the jugal.

In two young macaques the inferior orbital fissure was large and the pterygo-maxillary fissure wide. This shows a less developed form of the postorbital wall.



GIBBON [Hylobates] Fig. 10. ORANG [Simia] Fig. 11.

GORILLA [Gorilla] male; female was the same Fig. 12. CHIMPANZEE [Anthropithecus troglodytes] Fig. 13.

Fig. 10 - 13

The remaining examples of the Cercopithecidae (fig. 8) are similar to the macaques, except in *Cynocephalus* (fig. 9). Here the posterior wall is complete and the inferior orbital fissure is not visible from the lateral aspect. The bones that form the borders of the fissure are the same as in the macaques but the temporal bone runs forward to make contact with the jugal bone, separating the frontal from the sphenoid.

Gibbon (fig. 10)

Unfortunately, in the specimen available, the suture lines were mainly obliterated but the zygomatico-frontal, zygomatico-parietal, zygomatico-maxillary, and palato-maxillary sutures were detectable. The boundaries of the inferior orbital fissure are formed by the sphenoid and jugal above and laterally, the maxilla and palatine below and medially, and the sphenoid and palatine behind. The inferior orbital fissure is quite wide, especially at the posterior end.

The postorbital wall is formed mainly by the jugal bone, with the greater wing of the sphenoid forming the posterior portion and the frontal the superior portion.

ORANG (fig. 11)

Once again, most of the sutures had fused, but it was possible to tell that the walls of the inferior orbital fissure are formed by the same bones as in the gibbon. However, the palatine plays only a small part in forming the lower and posterior wall as compared with the condition in the gibbon. The fissure is a narrow slit.

The postorbital wall is composed of the jugal, the greater wing of the sphenoid and the frontal. It is doubtful whether the maxilla could be considered to take part.

THE GORILLA (fig. 12)

Two specimens of gorilla were examined, a male and a female. Although the female skull was much smaller than the male, the postorbital wall was exactly the same.

The inferior orbital fissure is at the junction of the floor and the lateral wall of the orbit. The boundaries are: the greater wing of the sphenoid above and behind, the jugal in front, and the maxilla and palatine below and medially. The greater wing of the sphenoid has well overlapped the border of the maxilla, giving the inferior orbital fissure a downwards direction. This condition was more marked in the gorilla than in the orang. The overlapping sphenoid close to the maxilla reduces the fissure to a narrow slit.

THE CHIMPANZEE (fig. 13)

Three chimpanzees were examined and they showed considerable differences.

In all three the postorbital wall is formed by the frontal above, the jugal in front, and the greater wing of the sphenoid behind.

Two skulls had wide inferior orbital fissures, unobstructed by a sphenoidal flange, and the inferior orbital grooves were plainly visible. The pterygo-maxillary fissure was wide and the palatine could be seen through it in the floor of the pterygo-palatine fossa. The spheno-palatine foramen could readily be seen from the lateral side. In the third specimen the inferior orbital fissure was also wide but the greater wing of the sphenoid overlapped the maxilla to produce a condition superficially resembling that found in the gorilla. The pterygo-maxillary fissure was the same as in the other specimens.

It is interesting to note that in the Family Simiidae, the inferior orbital fissure has moved downwards and occupies the infero-lateral angle of the orbit. The maxilla forms the lower border of the fissure. This is different from all observed specimens of the Cercopithecidae where the inferior orbital fissure is in the middle or lower portion of the postorbital wall, hence allowing the maxilla to form part of the postorbital wall.

Man

The development of the postorbital wall has been dealt with in the first part of this paper. The gorilla and the orang betray more marked differentiation in this part than does man whose inferior orbital and pterygomaxillary fissures are relatively large as in the chimpanzee. Martin (1928) gives the following areas for comparison in size:

Anthropoids	....	4 - 7 sq. mm.
Europeans	....	58 - 61 „ „

The object here is to deal with the postorbital wall in man and to determine—

(a) if there are any variations that may distinguish different ethnological groups.

(b) the form of these variations and the reason, if any, for their occurrence.

Authors who have generalised on this part of the skull have hinted that ethnological differences occur. Martin (1928) says that the negro has the largest inferior orbital fissure, while in the Japanese it is mainly narrow and looks downwards. Wood Jones (1930) lists the spheno-maxillary fissure among the morphological features that should be taken into account when examining a skull for "racial" distinction. Others stress the large size of the fissure in the Australian aborigine. These statements seem to rest upon simple visual observations on small numbers of skulls. It is felt that more reliable conclusions might emerge from statistical analysis of measurements made upon a larger number of skulls.

One hundred Australian aboriginal skulls, mostly of South Australian origin, ten European, three Chinese, two Japanese, and four African skulls were examined. To avoid unnecessary complication only male skulls were selected. It is unfortunate that more non-aboriginal skulls were not available for comparison.

The Australian Aboriginal Skull (fig. 15)

The postorbital wall is formed mainly by the zygomatic bone anteriorly and the greater wing of the sphenoid posteriorly. The frontal and the maxilla may play a part in the wall on the extreme superior and inferior borders respectively. There is a certain amount of individual variation in the size and shape of these bones and when the zygomatic and the sphenoid meet the frontal at a more inferior level than usual the frontal forms part of the postorbital wall. Similarly, the maxilla may have a process that runs up the anterior border of the inferior orbital fissure, so becoming one of the bones of the postorbital wall.

The suture lines show only small individual variations. The borders of the inferior orbital fissure are formed by the sphenoid, zygomatic and the maxilla, except in 28%, where a spheno-maxillary junction excludes the zygomatic bone.

The inferior orbital fissure at first glance appears to have no particular shape, but on closer analysis three main types can be distinguished, as noted by Wood Jones (1930). The first is the "narrow" type, the second is the "wide" type, and the third is the "wide at the anterior end" type (fig. 15).

In the hundred skulls examined, type three represented 48%, while types one and two represented 24% and 28% respectively. With each of these three main types there may be two additional variations. The sphenoid may be close to the maxilla or it may be some distance laterally. Using these two variations, six subtypes can be formed. The type with the sphenoid close to the maxilla and with a narrow inferior orbital fissure has the most complete postorbital wall, while the type with a wide fissure and well separated sphenoid has the most deficient postorbital wall.

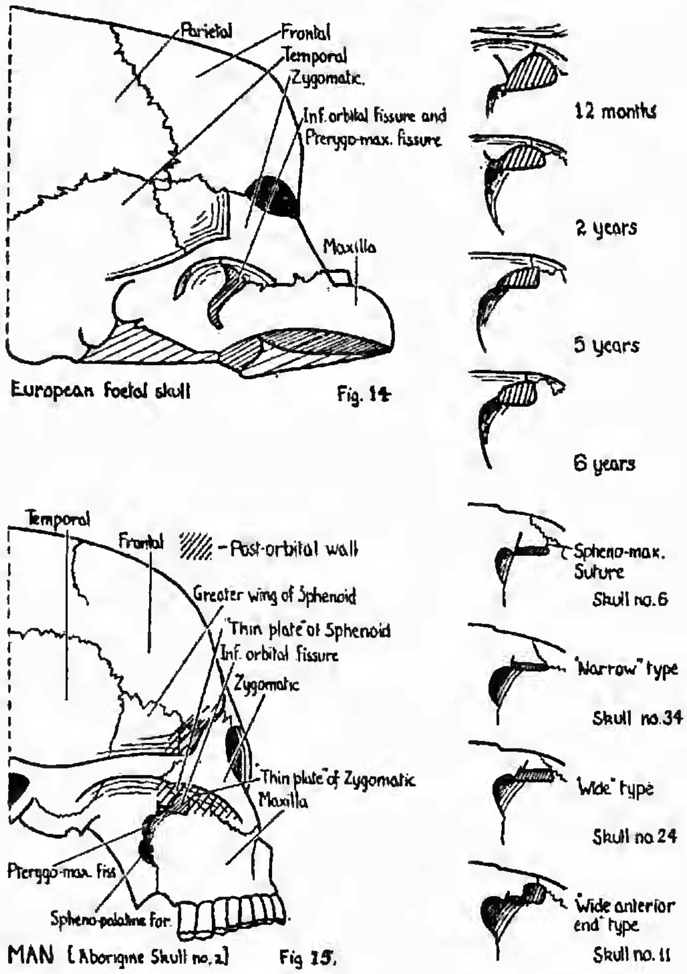


Fig. 14 - 15

The pterygo-maxillary fissure is a part of the general spheno-maxillary system. It continues the posterior end of the inferior orbital fissure, and for completeness must be considered also. For each skull a record was kept of the depth (either deep or shallow) and of the width (wide or narrow). There seemed to be no size relationship between the two fissures. In many cases a wide pterygo-maxillary fissure was associated with a narrow inferior orbital fissure. The infra-temporal surface of the sphenoid plays a part in the lateral projection of the area of the inferior orbital fissure. Although that surface does not alter the actual size of the fissure it may, as a spine, crest or thick bulge, hide the posterior end of the inferior orbital fissure from the lateral view to a varying degree.

The greater wing of the sphenoid, as it forms the superior border of the inferior orbital fissure, may be divided into two parts. The posterior part is thick in the region of the infra-temporal crest and the pre-pterygoid spine, but the anterior part is a thin plate. This thin plate is in contact with a thin plate-like extension from the zygomatic (fig. 15, skull No. 2). Most variations in the inferior orbital fissure occur where these thin plates meet.

The size of the anterior end of the inferior orbital fissure depends upon the degree of development of these plates, and on the distance the sphenoid is lateral from the maxilla.

Reference to the foetal skull is instructive (fig. 14). The fissure is wide and runs downwards into the pterygo-palatine fossa, connecting this fossa with the orbit. In the 12-month-old skull (fig. 14), the inferior orbital fissure is still wide but the pterygo-maxillary fissure has become narrower. In the 2, 5, and 6-year-old skulls (fig. 14), the thicker part of the sphenoid has grown down in the region of the infra-temporal crest, but the thin plates of the sphenoid and zygomatic are undeveloped, leaving the fissure still widely open in front. It is easy to see that, from this generalised stage, the inferior orbital fissure could either remain wide or narrow to a slit according to the amount of subsequent expansion of the two thin plates. In the foetus the horizontal projection of the area of the fissure is large and the sphenoid is well lateral to the maxilla. The area may remain large in the adult skull or it may be decreased either by enlargement of the maxillary sinus or by medialwards expansion of the sphenoid.

Three aboriginal skulls have been chosen which show the three most common variations in this region.

Skull No. 24 (fig. 15) shows the usual formation of bones in the postorbital wall, with zygomatic anteriorly, greater wing of the sphenoid posteriorly and the frontal superiorly.

The bones forming the boundary of the inferior orbital fissure are of the common pattern. The greater wing of the sphenoid forms the posterior border, the zygomatic, maxilla and palatine forming the anterior, inferior and posterior borders respectively.

In this case the inferior orbital fissure is exceptionally wide and can be classified as the "wide" type. The pterygo-maxillary fissure is also wide.

In skull No. 6 (fig. 15), the boundaries of the inferior orbital fissure show some variation. The posterior, superior, and inferior borders of the fissure are formed by the palatine, the greater wing of the sphenoid and the maxilla respectively. The maxilla has sent a process in a postero-superior direction to meet the sphenoid and exclude the zygomatic from the fissure. This small maxillary tongue thus forms part of the postobital wall. The inferior orbital fissure is small and well covered by the pre-pterygoid spine of the sphenoid, and is typical of the "thin" type. The pterygo-maxillary fissure is narrow and the pterygo-palatine fossa small.

Skull No. 11 (fig. 15) shows the "wide at the anterior end" type. The two thin plates of the sphenoid and the zygomatic are not so well developed and have left a large opening in the anterior end of the fissure.

The following measurements were made on the right side of all the skulls employed for this investigation. No female skulls were measured but the female skulls examined were similar to the male. In two skulls of 11 and 12-year-old aborigines, the normal adult form was present. Evidently the final pattern is attained relatively early and this would account for absence of obvious sexual distinction (see Abbie, 1947).

1. The length of the fissure.—i.e., from the palatine to the most anterior point of the fissure.
2. The maximum width.—This was found in most cases to be at the anterior end, but in a few in the middle or the posterior end.

3. Width at the anterior end.—This was in most cases the same as the maximum width.
4. Width at the pterygo-palatine end.—This was variable, in some cases the end was large and rounded, in others just a narrow slit.
5. Distance of the sphenoid from the maxilla.—This figure was arrived at by averaging the horizontal widths at the anterior end, the middle and the posterior end. The mean of these figures gave a basis for comparison between different skulls.
6. Area from lateral side.—This is the horizontal projection of the area of the fissure.
7. Area from the base of the skull.—This is the vertical projection of the area of the fissure.

The measurements were recorded in Tables I, II and III (Appendix 1). All figures were examined for their degree of variability. Those obtained at the 5% level are as follows (all measurements in mm.).

1. Length of fissure - - - - -	between	35.3 and 24.6
2. Maximum width - - - - -	„	7.9 and 2.1
3. Width at anterior end - - -	„	8.3 and 1.5
4. Width at pterygo-palatine end -	„	4.9 and 1.5
5. Distance sphenoid from maxilla -	„	4.1 and 0.9
6. Area from lateral side - - -	„	92.5 and 0
7. Area from base - - - -	„	118.6 and 13.3

Take 1 as an example. There is a difference of range of 10.7 mm. This is 38% of the mean length of the fissure (30 mm.). The other figures show an even greater percentage variation. In the face of such variation it is impossible to give any definite size or shape for the inferior orbital fissure in the South Australian skull (Appendix 2).

Similar tests were applied to the European, Chinese and African skulls. Once again, no standard pattern could be found. Thus, so far as this comparative material goes, there appear to be no standard shapes or sizes of the inferior orbital fissure in different peoples. With this variation, it would seem unlikely that there is any ethnological significance in the size and shape of the fissure. This conclusion is confirmed by statistical analysis of the measurements taken (Appendix).

Combining the aboriginal skulls and the European in the "t" test for these figures, no significance was found in any of them at the 5% level (Appendix). This shows that, as far as these observations go, there is no significant difference between the South Australian aboriginal and European inferior orbital fissures. This is contrary to what might be gathered from inspection alone. Similar "t" tests were carried out between the Aboriginal and the Chinese and African skulls, and once again no significant difference was found.

ACKNOWLEDGMENTS

I am indebted to Professor A. A. Abbie for suggesting this subject for investigation and for advice and assistance throughout. I am also indebted to the Director of the South Australian Museum, who allowed me to use material in the Museum collection.

RECAPITULATION

1. Separation of the orbit from the temporal fossa has been followed from fishes up to man.

2. The postorbital wall, which effects this separation, is formed mainly by flange-like extensions from the surrounding bones—frontal, sphenoid and zygomatic. The maxilla is sometimes involved. Communication with the temporal and infratemporal regions is gradually reduced to a spheno-maxillary fissure which becomes partially differentiated into a pterygo-maxillary fissure and an inferior orbital fissure.
3. The first stage of this process in primates is seen in the lemur. It reaches an extreme, reducing the inferior orbital fissure in particular to a narrow slit, in the Cercopithecidae and in the orang and gorilla. The condition is less extreme, and the fissures are generally wider, in the gibbon and chimpanzee and in man. A limited phylogenetic survey indicates that the final form of the inferior orbital fissure is determined largely by the development of thin, plate-like extensions from the sphenoid and zygomatic. The final form is, apparently, attained relatively early in development.
4. In man the inferior orbital fissure shows a wide range of variation in size and shape. Statistical comparison of the Australian aborigine with a limited number of skulls of different origin disclosed no signicant ethnological distinction.

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APPENDIX 1

TABLE I — ABORIGINAL SKULLS

	1	2	3	4	5	6	7
No. of skull	Length of fissure	Maximum breadth	Width at anterior end	Width of Pterygo-palatine fossa end	Distance sphenoid is lateral from maxilla	Area from lateral side	Area from base
1	33	5	5	1	4	42	50
2	31	6	6	3	3	29	62
3	28	5	4	5	4	15.5	89
4	29	4	4	3.5	3	24	69
5	30	6	6	2	2.5	36.5	71
6	31	3	3	1.5	1.5	4	51
7	32	4	4	4	3	21	86
8	30	5	3.5	5	3	36	96
9	30	6	6	3.5	2.5	26	63
10	30	7	7	4	4	47	89
11	30	8	8	2	2	35	71
12	27	4	4	2	1.5	27	34
13	34	6	2	2	2.5	54	86
14	30	7	7	4	2	108	72
15	25	7	7	2	3	46	70
16	28	5	5	2	3	21	63
17	28	5	5	3	2	19	61
18	29	7	7	1	1.5	30	53
19	28	2.5	2.5	2	1	10	30
20	25	5	5	2	4	10	43
21	37	7	7	4	4	53	92
22	26	2	1	2	1	11	7
23	30	3	3	2	1.5	22	30
24	33	6	6	2	2.5	58	68
25	31	5	5	5	3.5	21	85
26	28	5	5	4	2.5	34	57
27	31	4	4	3	3	21	51
28	22	4	4	2	2	15	34
29	31	5	5	3	3	25	76
30	31	7	7	2	2.5	47	59
31	28	6	6	3	3	40	99
32	34	5	5	4	2.5	20	82
33	33	6	5	2	2.5	50	87
34	33	3	3	3	2	2	47
35	28	7	7	2	2	52	57
36	27	7	7	2	3	36	62
37	27	3	1	3	1.5	2	31
38	34	4	4	4	3	15	87
39	32	5	5	4	3	13	52
40	33	5	5	3	3	21	64
41	23	4	4	4	2.5	10	39
42	32	7	2	4	3	49	86

TABLE 2

ABORIGINAL SKULLS (continued)

	1	2	3	4	5	6	7
No. of skull	Length of fissure	Maximum breadth	Width at anterior end	Width of Pterygo-palatine fossa end	Distance sphenoid is lateral from maxilla	Area from lateral side	Area from base
43	30	5	5	2	2	44	76
44	34	7	7	2	3	101	45
45	32	5	5	3	2.5	39	87
46	30	3	2	3	2	4	25
47	31	5	5	3	2	58	74
48	32	5.5	5.5	4	2.5	52	87
49	25	9.5	9.5	4	3	33	57
50	30	5	5	5	3	54	81
51	30	4	4	2	1.5	23	42
52	30	7	7	3	2	47	63
53	29	3	2	3	2	7	58
54	33	4.5	4.5	3	2.5	58	88
55	26	1	4	4	2	0	56
56	34	11	11	5	6	215	203
57	28	4	4	3	2	11	63
58	35	6	6	3	2.5	85	95
59	32	5	5	3	2.5	53	90
60	34	4	4	3	2.5	67	71
61	25	2	2	1	1	8	27
62	32	6	6	4	3	61	77
63	32	4	4	4	2.5	37	80
64	30	2	2	2	2	15	42
65	28	4	4	4	2	6	49
66	30	4	4	3	2.5	10	65
67	25	3	3	3	2	6	55
68	35	6	6	3	2.5	44	68
69	28	4	4	3	2	45	49
70	25	6	6	5	2	43	77
71	35	8	8	3	2.5	71	77
72	30	5	5	3	2	47	59
73	29	4	4	3	2.5	61	53
74	30	4	4	4	2.5	41	63
75	31	7	7	3	2	76	61
76	29	3	3	3	2	20	50
77	30	4	4	3	2.5	29	70
78	29	5	5	3	2	38	53
79	28	5	5	4	3	34	64
80	32	7	7	3	3	75	90
81	29	4	4	4	2.5	20	86
82	31	2	2	1.5	1.5	0	35
83	29	4	2	4	2	18	51
84	30	6	6	4	3	53	89

TABLE 3

ABORIGINAL SKULLS (continued)

No. of skull	1 Length of fissure	2 Maximum breadth	3 Width at anterior end	4 Width of Pterygo-palatine fossa end	5 Distance sphenoid is lateral from maxilla	6 Area from lateral side	7 Area from base
85	31	5	6	6	3.5	36	103
86	30	4	4	4	2.5	8	70
87	27	5	5	4	3	50	82
88	31	6	6	4	3	47	83
89	32	3	3	3	2	29	47
90	32	5	5	3	2	38	52
91	32	6	6	4	3	62	102
92	29	6	6	4	2.5	48	74
93	27	6	6	5	3	54	123
94	29	4	3.5	4	3	7	80
95	25	4	4	3	2.5	4	55
96	30	6	6	4	2.5	62	87
97	32	4	4	4	2	38	68
98	30	5	5	3	2.5	29	85
99	31	7	7	4	3.5	79	116
100	31	4	4	2	1.5	19	50
EUROPEAN SKULLS							
1	28	4	4	3	2.5	35	62
2	28	6	6	5	2	39	75
3	28	3	3	3	2	9	37
4	29	5	5	4	2	40	65
5	32	3	3	3	2.5	30	91
6	25	5	5	3	2	21	32
7	27	4	4	3	2.5	17	61
8	27	7	7	3	2	34	43
9	27	4	3	4	2	9	50
10	31	5	5	3	2.5	31	59
AFRICAN SKULLS							
1	30	7	7	4	2.5	65	64
2	27	8	8	4	3	64	97
3	27	8	8	4	2.5	67	82
4	29	3	3	2	2	34	51
CHINESE SKULLS							
1	32	4	2	4	2	20	74
2	30	5	5	2	1.5	42	34
3	30	3	3	2	1.5	10	39
JAPANESE SKULLS							
1	28	2	1	2	1.5	3	37
2	32	7	7	4	3	30	87

APPENDIX 2

LENGTH OF FISSURE

Aboriginal.

$Sx_1^2 = 90558$

$Sx_1 = 2997$

$\bar{x}_1 = 29{\cdot}97$

$\sigma_1^2 = 90558 - 89820$

$= \underline{\underline{738}}$

$\frac{(29{\cdot}97 - \alpha)100}{\sqrt{738}} = \pm t{\cdot}05$ with 99 d.f.

$= \pm 1{\cdot}98$

$29{\cdot}97 - \alpha = \pm 5{\cdot}36$

$\therefore \alpha$ between 35·3 & 24·6

European.

$Sx_2^2 = 7990$

$Sx_2 = 282$

$\bar{x}_2 = 28{\cdot}2$

$\sigma_2^2 = 7990 - 7950$

$= \underline{\underline{40}}$

Combined.

$\sigma(\bar{x}_1^2 - \bar{x}_2) = \frac{\sigma_1^2}{100} + \frac{\sigma_2^2}{10}$

$= 7{\cdot}38 + 4 = 11{\cdot}38 = (3{\cdot}37)^2$

$t = \frac{1{\cdot}8}{3{\cdot}37} = \underline{\underline{{\cdot}53}}$ at 110 d.f.

not significant ($P \doteqdot {\cdot}6$)

MAXIMUM WIDTH

Aboriginal.

$Sx_1^2 = 2776$

$Sx_1 = 504{\cdot}5$

$\bar{x}_1 = 5{\cdot}0$

$\sigma_1^2 = 2776 - 2545$

$= \underline{\underline{221}}$

$\frac{(5{\cdot}0 - \alpha)100}{221} = \pm t{\cdot}05$ with 99 d.f.

$= 1{\cdot}98$

$5{\cdot}0 - \alpha = \pm 2{\cdot}9$

$\therefore \alpha$ between 7·9 & 2·1

European.

$Sx_2^2 = 226$

$Sx_2 = 46$

$\bar{x}_2 = 4{\cdot}6$

$\sigma_2^2 = 226 - 211{\cdot}6$

$= \underline{\underline{14{\cdot}4}}$

Combined.

$\sigma(\bar{x}_1^2 - \bar{x}_2) = \frac{\sigma_1^2}{100} + \frac{\sigma_2^2}{10}$

$= 2{\cdot}21 + 1{\cdot}44 = 3{\cdot}65 = (1{\cdot}91)^2$

$t = \frac{{\cdot}4}{1{\cdot}91} = \underline{\underline{{\cdot}209}}$ at 110 d.f.

not significant ($P \doteqdot {\cdot}83$)

WIDTH AT ANTERIOR END

Aboriginal.

$Sx_1^2 = 2640{\cdot}5$

$Sx_1 = 484{\cdot}6$

$\bar{x}_1 = 4{\cdot}9$

$\sigma_1^2 = 2640{\cdot}5 - 2342$

$= \underline{\underline{298{\cdot}5}}$

$\frac{(4{\cdot}9 - \alpha)100}{298{\cdot}5} = \pm t{\cdot}05$ with 99 d.f.

$= \pm 1{\cdot}98$

$(49 - \alpha) = \pm 3{\cdot}42$

$\therefore \alpha$ between 8·3 & 1·5

European.

$Sx_2^2 = 219$

$Sx_2 = 45$

$\bar{x}_2 = 4{\cdot}5$

$\sigma_2^2 = 219 - 202{\cdot}5$

$= \underline{\underline{16{\cdot}5}}$

Combined

$\sigma(\bar{x}_1^2 - \bar{x}_2) = \frac{\sigma_1^2}{100} + \frac{\sigma_2^2}{10} = 2{\cdot}99 - 1{\cdot}65$

$= 4{\cdot}64 = (2{\cdot}154)^2$

$t = \frac{{\cdot}4}{2{\cdot}154} = \underline{1857}$ at 110 d.f.

not significant ($P \doteqdot {\cdot}85$)

WIDTH AT PTERYGO-PALATINE FOSSA END

Aboriginal.

$Sx_1^2 = 1101$

$Sx_1 = 320{\cdot}5$

$\bar{x}_1 = 3{\cdot}2$

$\sigma_1^2 = 1101 - 1027$

$= \underline{\underline{74}}$

$\frac{(3{\cdot}2 - \alpha)100}{74} = \pm 1{\cdot}98$

$3{\cdot}2 - \alpha = \pm 1{\cdot}7$

$\therefore \alpha$ between 4·9 & 1·5

European.

$Sx_2^2 = 120$

$Sx_2 = 34$

$\bar{x}_2 = 3{\cdot}4$

$\sigma_2^2 = 120 - 115{\cdot}6$

$= \underline{\underline{4{\cdot}4}}$

Combined.

$\sigma(\bar{x}_1^2 - \bar{x}_2) = \frac{\sigma_1^2}{100} + \frac{\sigma_2^2}{10} = {\cdot}74 + {\cdot}44$

$= 1{\cdot}18 = (1{\cdot}086)^2$

$t = \frac{{\cdot}2}{1{\cdot}086} = \underline{{\cdot}1841}$ at 110 d.f.

not significant ($P \doteqdot {\cdot}85$)

DISTANCE SPHENOID IS LATERAL FROM MAXILLA.

Aboriginal.

$Sx_1^2 = 686 \cdot 75$

$Sx_1 = 284 \cdot 5$

$\bar{x}_1 = 2 \cdot 5$

$\sigma_1^2 = 686 \cdot 75 - 617 \cdot 7$

$= \underline{69 \cdot 1}$

$\frac{(2 \cdot 5 - \alpha)100}{69 \cdot 1} = \pm 1 \cdot 98$

$2 \cdot 5 - \alpha = \pm 1 \cdot 64$

$\therefore \alpha$ between $4 \cdot 1$ & $\cdot 9$

European.

$Sx_2^2 = 49$

$Sx_2 = 22$

$\bar{x}_2 = 2 \cdot 2$

$\sigma_2^2 = 49 - 48 \cdot 4$

$= \underline{\cdot 6}$

Combined

$\sigma(\bar{x}_1^2 - \bar{x}_2) = \frac{\sigma_1^2}{100} + \frac{\sigma_2^2}{10} = \cdot 69 + \cdot 06$

$= \cdot 751 = (\cdot 866)^2$

$t = \frac{\cdot 3}{\cdot 866} = \underline{\cdot 347}$ at 110 d.f.

not significant ($p \doteqdot \cdot 73$)

AREA FROM LATERAL SIDE

Aboriginal.

$Sx_1^2 = 217431 \cdot 5$

$Sx_1 = 3785$

$\bar{x}_1 = 37 \cdot 85$

$\sigma_1^2 = 217431 - 143300$

$= \underline{74131}$

$\frac{(38 \cdot 39 - \alpha)100}{74131} = \pm 1 \cdot 95$

$38 \cdot 39 - \alpha = \pm 54 \cdot 1$

$\therefore \alpha$ between $92 \cdot 5$ & 0.

European.

$Sx_2^2 = 8255$

$Sx_2 = 265$

$\bar{x}_2 = 26 \cdot 5$

$\sigma_2^2 = 8255 - 7021$

$= \underline{1234}$

Combined.

$\sigma(\bar{x}_1^2 - \bar{x}_1) = 701 \cdot 3 + 123 \cdot 4$

$= 824 \cdot 7 = (28 \cdot 718)^2$

$t = \frac{11 \cdot 89}{28 \cdot 72} = \underline{\cdot 414}$ at 110 d.f.

not significant ($p \doteqdot \cdot 68$)

AREA FROM BASE

Aboriginal.

$Sx_1^2 = 522361$

$Sx_1 = 6699$

$\bar{x}_1 = 66 \cdot 99$

$\sigma_1^2 = 522361 - 448700$

$= \underline{73461}$

$\frac{(66 \cdot 99 - \alpha)100}{73461} = \pm 1 \cdot 98$

$66 \cdot 99 - \alpha = 53 \cdot 67$

$\therefore \alpha$ between $118 \cdot 6$ & $13 \cdot 3$

European.

$Sx_2^2 = 35919$

$Sx_2 = 575$

$\bar{x}_2 = 57 \cdot 5$

$\sigma_2^2 = 35919 - 33070$

$= \underline{2849}$

Combined.

$\sigma(\bar{x}_1 - \bar{x}_2)^2 = 734 \cdot 61 + 284 \cdot 9 = 1019 \cdot 5 = (31 \cdot 93)^2$

$t = \frac{9 \cdot 49}{31 \cdot 93} = \underline{0 \cdot 297}$ at 110 d.f.

not significant ($p \doteqdot \cdot 77$)